

**AMENDMENTS TO THE SPECIFICATION:**

*Please amend the paragraphs beginning at page 1, line 9, and continuing to page 1, line 14, as follows:*

The invention refers to ~~a method for enhancing the measuring accuracy in an antenna array comprising a number of antenna elements. The A~~ method comprises the ~~steps-acts of;~~

- receiving analog signals on a number of m antenna array elements, and;
- producing a radiation diagram for the array from the values in the signals.

The ~~invention-technology~~ also refers to an antenna array system comprising

*Please amend the paragraph beginning at page 2, line 27, and continuing to page 2, line 30, as follows:*

It is a desirable feature for an antenna system to have the ability to detect and estimate the direction of arrival of the target with a reasonable probability (reasonably low standard deviation). An optimum is thus sought for the trade ~~off~~ between low standard deviation and low SNR.

*Please amend the paragraph beginning at page 4, line 10, and continuing to page 4, line 14, as follows:*

It is an object of the ~~invention-technology~~ to diminish random errors regarding the resolving probability of the target when trying to narrow the main lobe, in order to get better estimation of the direction-of-arrival of a target. It is thus an object of the ~~invention~~

technology to eliminate the grating lobe problem when trying to “zoom in” on a target, i.e. to achieve a better measuring accuracy.

*Please amend the caption on page 4, line 16 as follows:*

DISCLOSURE OF INVENTIONBRIEF SUMMARY

*Please amend the paragraphs beginning on page 4, line 17, and continuing to page 4, line 25, as follows:*

The invention-technology intends to meet the above objectives with a method for enhancing the measuring accuracy in an antenna array comprising a number of antenna elements. <sup>1</sup>

The method comprises the steps-acts of:

- receiving analog signals with the antenna array elements, and;
- producing values for a radiation diagram from the values in the signals, where the radiation diagram displays a main lobe and grating lobes when present.

*Please amend the paragraph on page 5, line 9, as follows:*

The invention-technology is characterised in that the method comprises the steps acts of:

*Please amend the paragraph beginning on page 5, line 27, and continuing to page 6, line 2, as follows:*

The first part of step-act a) is to receive analog signals on all antenna elements at a first time  $t_1$ . The antenna elements are advantageously placed in the antenna array with

their relative distance equal to or greater than the wavelength divided by two. The wavelength refers to the frequency used in the antenna array system. The relative distance of the antenna elements fulfils the Nyqvist criteria which is why there will be no grating lobes appearing in the radiation diagram when using a full array.

*Please amend the paragraphs beginning on page 6, line 20, and continuing to page 6, line 27, as follows:*

Below the ~~invention-technology~~ will be described as finding values in the radiation diagrams. However, the ~~invention-technology~~ may instead use the technique of finding the values in the vectors generating the radiation diagrams. The two techniques shall be seen as essentially equivalent to each other.

According to ~~step-act b)~~, the antenna elements may be switched off or reduced by using antenna elements that may be manipulated, for example electronically.

*Please amend the paragraph beginning on page 9, line 17, and continuing to page 9, line 23, as follows:*

~~Step-Act b)~~ and ~~step-act c)~~ may be repeated in time until the antenna array comprises only the two outermost antenna elements. This antenna configuration generates the narrowest main lobe with the lowest amplitude and the highest grating lobes. Thus, this configuration produces a radiation diagram where it may be difficult to find the maximum point for the main lobe. The grating lobes may actually be as high as the main lobe for some antenna configurations.

*Please amend the paragraph beginning on page 10, line 1, and continuing to page 10, line 19, as follows:*

The radiation diagrams comprise the values of the gain  $G(\theta)$  versus the azimuth angle  $\theta$ . Since the number of antenna elements at the second time  $t_2$  is less than the maximum number of antenna elements, grating lobes will appear in the second radiation diagram. Consequently, since the antenna configuration at a third time  $t_3$  has even lesser antenna elements, more grating lobes will appear in a third radiation diagram. In the second and third radiation diagram the grating lobes appear at different angles dependent on which and how many antenna elements that has been switched off or reduced. In the second radiation diagram the first grating lobes appear on each side of the main lobe at certain angles, e.g.  $\theta_{t2} = X_{t2}$  radians (or degrees) and  $\theta_{t2} = -X_{t2}$  radians (degrees). In the third radiation diagram the first grating lobes appear on each side of the main lobe at certain angles, e.g.  $\theta_{t3} = X_{t3}$  radians (or degrees) and  $\theta_{t3} = -X_{t3}$  radians (degrees).

According to the invention technology,  $X_{t2}$  is greater than  $X_{t3}$  and  $-X_{t2}$  is lesser than  $-X_{t3}$ , i.e. the first grating lobes in the third radiation diagram appear closer to the main lobe than the first grating lobes in the second radiation diagram. The third radiation diagram presents a second range outside which the grating lobes will appear. According to the above the second range must be narrower than the first range.

*Please amend the paragraphs beginning on page 10, line 29, and continuing to page 11, line 14, as follows:*

In another example embodiment of the invention, a number of radiation diagrams will be produced for every antenna array configuration. The number of radiation diagrams may be used for calculating a mean value for the antenna array configuration, i.e. a mean value for the gain at different angles. A mean value may be calculated by any known methods e.g. Bartlett. Furthermore, when calculating a number of radiation diagrams for each time, it is possible to reject all radiation diagrams where the maximum is found/calculated outside the range. This increases the measuring accuracy since the desired maximum value for the main lobe may be found in at least one radiation diagram.

The invention-technology may thus be used by dynamically altering the antenna array such that interadjacent antenna elements are switched off or reduced until only the outermost antenna elements remain.

The benefits of the invention-technology above-method will become apparent when describing the example embodiments below.

*Please amend the paragraph beginning at page 11, line 25, and continuing to page 11, line 26, as follows:*

Fig. 1 shows an antenna array according to one example embodiment of the invention; with a number of  $t_1-t_4$  configurations in time.

*Please amend the paragraph beginning at page 12, line 29, and continuing to page 12, line 30, as follows:*

Fig 11 diagrammatically shows a block diagram over the method according to the invention-according to one example embodiment.

*Please amend the caption on page 13, line 1 as follows:*

#### MODES FOR CARRYING OUT THE INVENTIONDETAILED DESCRIPTION

*Please amend the paragraph beginning on page 13, line 14, and continuing to page 13, line 31, as follows:*

Fig. 1 shows an antenna array 1 according to one example embodiment of the invention-comprising five antenna elements 2, with a number of configurations in time.

The antenna elements 2 are depicted with a large X. At the first time  $t_1$  the antenna array 1 uses all of the antenna elements 2. At the second time  $t_2$  the antenna array 1 uses all but one of the antenna elements 2. At the third time  $t_3$  the antenna array 1 uses all but two of the antenna elements 2. At the fourth time  $t_4$  the antenna array 1 uses all but three of the antenna elements 2. As can be seen in fig. 1, the configuration of the antenna array 1 at the fourth time  $t_4$  uses only the two most widely separated antenna elements 2.

~~With “not~~ Not using” an antenna element or “removing” one antenna element, means that the signals from the antenna array 1 are reduced or blocked. This is advantageously done before the sampling of the signals, but may be carried out after the sampling. However, if the antenna elements 2 are to be reduced or blocked after the sampling, the system should require one sampling device per antenna element. In fig. 1 the reduced antenna elements 2 are depicted with a small x and denoted with 2'.

*Please amend the paragraph beginning on page 18, line 25, and continuing to page 19, line 8, as follows:*

The grating lobes 7 will appear closer to the main lobe 6 for each time that an antenna element 2 is removed and the main lobe 6 will become narrower. In figs. 6-8 the advantage of the ~~invention technology~~ is apparent, where the rejection of the grating lobes 7 for the different times generate a possibility to gain a narrow main lobe 6 that enables a good measuring accuracy of a target.

Fig. 9 schematically shows a graph depicting the Cramér-Rao Lower Boundary (CRB) and the standard deviation  $\sigma$  versus the Signal to ~~Noise~~ Noise Ratio (SNR). The standard deviation is a deviation of the angle. Figure 9 also shows a first point  $P_1$  at a certain distance from CRB and a second point  $P_2$  at a second location. The first point  $P_1$

has a higher SNR and consequently a lower standard deviation  $\sigma$  than the second point  $P_2$ . However, a lower SNR allows more noise in the signal, which is why the antenna array 1 may be used for detecting a target at a further distance (or a smaller target) than with a system at the first point  $P_1$ , if the increase in the standard deviation can be accepted.

*Please amend the paragraph beginning on page 20, line 1, and continuing to page 20, line 6, as follows:*

When reducing the array according to the ~~invention-technology~~ the width of the main lobe 6 will decrease, and the threshold will move closer to the CRB with a demand for a higher SNR, than for the previous configuration of the array. This is depicted in fig. 9 where the second point  $P_2$  has moved to the fourth point  $P_4$ .

*Please amend the paragraph beginning on page 20, line 23, and continuing to page 20, line 30, as follows:*

According to the ~~inventiontechnology~~, the rejection of the grating lobes 7 outside the ranges for the different radiation diagrams, removes the jump from the second point  $P_2$  to a third point  $P_3$  as well as the jump from the fifth point  $P_5$  to a sixth point  $P_6$ . This is due to the fact that there will be no errors when calculating the maximum point 8 for the main lobe 6 since there are no maximum points from grating lobes 7 that can give rise to an error. In fig 9, this is depicted as moving the third point  $P_3$  to the third point prime  $P_3'$  and as moving the sixth point  $P_6$  to the sixth point prime  $P_6'$ .

*Please amend the paragraph beginning on page 21, line 1, and continuing to page 21, line 7, as follows:*

Fig. 10 shows a two-dimensional antenna array 1 system according to one example embodiment of the invention, with a number of configurations in time  $t_1$ ,  $t_m$ ,  $t_n$ . The antenna array 1 system comprises five rows along an Y-axis. Each row comprises ten antenna elements 2 along a Z-axis. The antenna elements 2 are reduced or switched off in the same manner as described in fig. 1. The invention technology described above is thus possible to use on two-dimensional antenna arrays

*Please amend the paragraphs beginning on page 21, line 19, and continuing to page 21, line 28, as follows:*

The invention technology may be used for a two-dimensional array as depicted in fig. 10. Fig 11 shows that the reduction of the two-dimensional antenna array 1 gives diminished ranges for the grating lobes 7 and a diminished width of the main lobe, as for the one-dimensional antenna array 1 as depicted in fig. 1. The grating lobes 7 may thus be rejected in a two-dimensional antenna array 1 system according to the above method.

Fig 12 shows a block diagram over the method according to the invention according to one example embodiment. The blocks in fig. 12 depict a number of means suitable for performing the method.

*Please amend the paragraph beginning on page 22, line 30, and continuing to page 23, line 2, as follows:*

The system comprises means 19 for repeating step act b) and step act c) such that the antenna configuration dynamically is altered such that interadjacent antenna elements 2 are switched off or reduced until only the outermost antenna elements 2 remain.